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RE: Managed Reliability Storage STL11874

Dear Mr. McCarthy:

6.14.05

In response to your letter of 5.03, a patent search has been conducted regarding the six independent claims of STL11874, and in particular for a method of operating a managed reliability data storage system, employing monitoring, diagnostics and scheduling, with adjusted usage with respect to an optimal usage model, and software data recovery.

A search in US Patents was conducted in:
DataProcessing, Class 705, Subclass: 009
Computers, Class 710, Subclass: 006
Memory, Class 711, Subclass: 118
Errors, Class 714, Subclasses: 020, 026 and 047.

US Patent Examiner J. Manoskey au2113, was consulted.

The following 20 US Patents and Pubs disclose automated and optimized storage management, as noted.

6883066 Herbst/ Seagate : "C1m1. A method of *optimizing cache management* in a data storage device..."

6880110 Largman : "C1m1. A method for *automated self-repair* of a computer...automatically and without user intervention *repairing the first storage to a known operational state* that supports normal mode operation..."

6789132 Hoskins/ Seagate : "1. A data storage device control module for controlling operational processes in a data storage device, comprising: ...a *scheduler module* operable to schedule the execution of the non-preemptive modules in the data storage device control module; and a *preemptive operating module*..."

6782455 Palanca : "...a method for *optimizing cache service requests*."

6766416 Bachmat : "Load balancing of activities on physical disk storage devices is accomplished by *monitoring reading and writing operations to logical volumes on the physical disk storage devices*...Statistics accumulated over an interval are then used to obtain access activity values for each logical volume and each physical disk drive. A statistical analysis selects one logical volume pair."

6744578 Bishop : "C1m3. The method of claim 2, wherein the step of generating the *write current* further includes the steps of *adjusting the voltage source to generate a desired write current* amplitude based on the resistances RC and RW."

6708175 Curran : "the present invention is directed to a method for *limiting access to files for a relatively short duration...*"

6629201 Dempsey : "C1m62. ...wherein cache block size is one of the caching parameters and *adjusting cache block size* comprises increasing or decreasing all cache blocks by a power of 2.

6628994 Turicchi : "A method for the automatic selection of *computer system parameter values to improve system performance.*"

6279108 Squires/ Seagate : "The plural control tasks include a rotational control task for determining an adjustment to the spin speed of the rotating media...The sector timing task also provides for *scheduling the rotation control* and track following task for execution during discrete intervals during the rotational period of the predetermined sector as well as *scheduling the re-execution of the sector timing task* with respect to the rotational period of another predetermined sector."

5944839 Isenberg : "system and method for the *automated maintenance* of a computer system."

5802069 Coulson : "C1m3. *The mass storage device* of claim 2, wherein: the mass storage device copies the deallocated sector list from mass storage device media to the host memory portion; the mass storage device accesses the deallocated sector list stored in the host memory portion to determine whether a sector of the mass storage device has been deallocated *and remapped* to another sector of the mass storage device..."

5678042 Pisello/ Seagate : "C1m1. A machine-implemented, *network management method* for managing a network of file servers..."

20050033625 Kline : "C1m1. A method for *scheduling the performance of maintenance tasks to maintain a system environment*, comprising: monitoring a parameter for a computer system to detect a need to perform at least one maintenance task..."

20040215912 Vergis : "The field of invention relates generally to computing system optimization; and, more specifically, to a method and apparatus to establish, report *and adjust system memory usage.*"

20040193827 Mogi : "...*management of the performance of a storage apparatus* is executed by using a *performance indicator*..."

20030219033 Silvester : "Clm21. The medium access control device of claim 20, wherein a memory allocation for each mode is *dynamically adjustable to optimize memory usage*."

20030188092 Heath/ Seagate : "Clm17. A disc drive comprising: a head disc assembly executing a first of a plurality of commands; and a control processor *scheduling a next optimum command*..."

20030101109 Kaneda : "CLM1. *An operating/managing system connected to a computer and at least two storage apparatuses*, comprising: ...information duplicating means for *controlling reading-out of information from said storage apparatus and writing-in* of said information into said storage apparatus on the basis of said information held in said storage apparatus information holding means; and volume requesting means for requesting allocation of a volume to said storage apparatus connected to said computer."

20020091722 Gupta : "1. A method of *managing I/O resources* in an information delivery environment, comprising *modeling utilization* of at least one of said I/O resources; and managing at least one of said I/O resources based at least in part on said modeled utilization."

During the course of this search, I uncovered this foreign reference.

EP1357464A2: Method, apparatus and program for *managing the operation of a storage device* 30 pages

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"CLM1. An operation management system comprising: a computer, a storage apparatus for storing write information or read information to or from said computer, a connecting apparatus for connecting said computer and said storage apparatus, and a management apparatus for management of said computer, said storage apparatus and said connecting apparatus, wherein said management apparatus comprises: a control unit for realizing the *management function through comprehensive process of characteristic information of said storage apparatus*, characteristic information of said connecting apparatus and characteristic information of said computer..."

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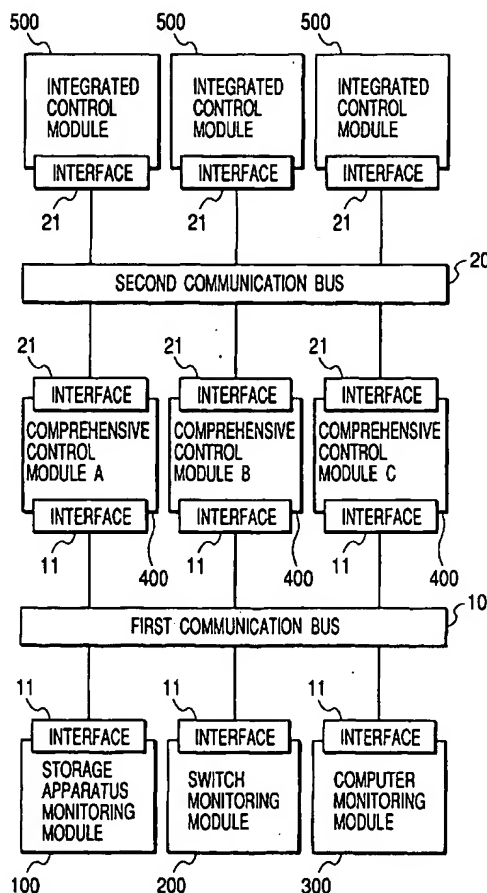
(54) **Method, apparatus and program for managing the operation of a storage device**

(57) An object of the present invention is to realize higher mutual connection property among the operation management applications because two interfaces of the first interface for the devices as the operation management object and the second interface provided by the operation management application which can be realized using the first interface are not yet specified simultaneously in the existing operation management system.

A management apparatus comprises a control unit for realizing a management function through comprehensive process of characteristic information of a storage apparatus, a connecting apparatus and a computer and an interface for receiving characteristic information from the storage apparatus, connecting apparatus and computer depending on the standard protocol among the management apparatus, storage apparatus, connecting apparatus and computer.

Moreover, an integrated management apparatus is also provided for integrated management based on the result of realization of a plurality of management functions. This integrated management apparatus includes an interface for receiving the result of realization of management function from the management apparatus depending on the standard protocol between the management apparatus and integrated management apparatus.

FIG. 1



Description

BACKGROUND OF THE INVENTION

[0001] The present invention relates to an operation management apparatus in an information processing system and particularly to an operation monitoring system and operation management system under the condition that a storage apparatus is configured using a network such as a fiber channel and Ethernet (Ethernet is the registered trade mark of Fuji Xerox Co., Ltd.).

[0002] A computer and a storage apparatus used in an information processing system have been connected using ATAPI (ATA Packet Interface) and SCSI (Small Computer System Interface). In the ATAPI, only two storage apparatuses of a master device and a slave device can be connected to only one cable because of its specification and moreover since the connection distance is short, the ATAPI has generally been used for connection of storage apparatus (mainly hard disk and CD-ROM) in the computer. The SCSI is specified with several specifications and eight devices in maximum may be connected with a daisy chain in the SCSI using the data bus width of eight bits. The SCSI has been used, in the computer system, as the major interface for connecting external storage apparatuses. However, with the connection distance and the limitation on the maximum configuration which is determined with electrical characteristics, it is now very difficult to configure a large scale storage system.

[0003] In these years, therefore, an information processing system has often been established using a network such as fiber channel and Ethernet because a storage system is increased in the physical size and an information processing system is further complicated. Particularly, a storage network which has been formed using a fiber channel is widely known as a SAN (Storage Area Network). In the storage network using the fiber channel and Ethernet, a more complicated system for wider area can be configured because it is possible to use various apparatuses such as switching device, hub and router or the like in comparison with the case where the ATAPI and SCSI are used.

[0004] For operation management of a more complicated storage system, it is essential to form an operation management system and an operation management method which can realize monitoring and controlling processes through effective comprehensive operation of storage apparatus, connecting apparatus and computer.

[0005] Fig. 2 illustrates a profile of the operation management in the prior art. Since storage apparatus, connecting apparatus and computer respectively have the inherent interfaces (interfaces A, B, C in the case of Fig. 2), the comprehensive control module includes the respective interfaces (interfaces A, B, C in the case of Fig. 2) of the storage apparatus, connecting apparatus and computer and the respective comprehensive control

modules (operation management applications) also include inherent interfaces (interfaces D, E, F in the case of Fig. 2). The integrated control module (moreover, the host operation management application) is requested to include respective interfaces (interfaces D, E, F in the case of Fig. 2) for comprehensive operation with the respective interfaces of the comprehensive control module. Moreover, for the comprehensive operation with the other comprehensive control modules, respective comprehensive control modules are requested to perform the comprehensive process via the provided interfaces. [0006] As described above, the operation management system of the prior art has no mutual connection capability among the operation management applications because two interfaces of the first interface for the apparatus as the operation management object and the second interface provided with the operation management application which is realized using the first interface are not specified simultaneously.

SUMMARY OF THE INVENTION

[0007] An object of the present invention is to provide higher mutual connection capability of the operation management application by specifying the first interface and the second interface.

[0008] In order to solve the object described above, a preferred embodiment of the present invention proposes an operation management system comprising a computer, a storage apparatus for storing write information or read information to the computer, a connecting apparatus for connecting the computer and the storage apparatus and a management apparatus for management of the computer, storage apparatus and connecting apparatus. Here, the management apparatus comprises a control unit to realize the management function through comprehensive process of the characteristic information of the storage apparatus, connecting apparatus and computer and an interface to receive the characteristic information from the storage apparatus, connecting apparatus or computer depending on the standard protocol between the management apparatus and storage apparatus and between the storage apparatus and computer.

[0009] Moreover, in the other embodiment of the present invention, the operation management system described above comprises an integrated management apparatus for the integrated management depending on the result of realization of a plurality of management functions and the integrated management apparatus also comprises an interface to receive the result of realization of the management function from the management apparatus depending on the standard protocol between the management apparatus and integrated management apparatus. In addition, the management apparatus comprises an interface to transmit the result of realization of the management function to the integrated management apparatus depending on the protocol.

[0010] In the other embodiment of the present invention, the management apparatus comprises a control unit to realize the management function by comprehensive process of the characteristic information of the storage apparatus, connecting apparatus and computer and an interface to receive the characteristic information from the storage apparatus, connecting apparatus and computer depending on the standard protocol between the management apparatus and storage apparatus and between the storage apparatus and computer. Moreover, the operation management system comprises the management apparatus for integrated management based on the result of realization of a plurality of management functions and the integrated management apparatus comprises an interface to receive the result of realization of the management function from the management apparatus depending on the standard protocol between the management apparatus and integrated management apparatus. In addition, the management apparatus comprises an interface to transmit the result of realization of management function to the integrated management apparatus depending on the protocol.

[0011] In the other embodiment of the present invention, a management apparatus comprises a control unit to realize the management function through comprehensive process of the characteristic information of the storage apparatus, connecting apparatus and computer and an interface to transmit and receive the result of realization of the management function among a plurality of management apparatuses depending on the standard protocol among a plurality of management apparatuses.

[0012] In the other embodiment of the present invention, the operation management system comprises a plurality of integrated management apparatuses for integrated management based on the result of realization of a plurality management functions. Here, the integrated management apparatus comprises an interface to transmit and receive the result of integrated management among a plurality of integrated management apparatuses depending on the standard protocol among a plurality of integrated management apparatuses. Moreover, the management apparatus comprises an interface to transmit the result of realization of management function to the integrated management apparatus depending on the protocol.

[0013] In the embodiment described above, it is more preferable that the characteristic information is expressed as CIM/XML and the control unit realizes the management function depending on the procedures specified with the CIM Operation over XML/HTTP.

[0014] Moreover, in the embodiment described above, it is more preferable that the result of realization of management function is expressed as XML and the integrated management apparatus is integrally administered depending on the procedures specified with the SOAP.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015]

Fig. 1 is an architecture diagram of an operation management system as a preferred embodiment of the present invention.

Fig. 2 is an architecture diagram of an operation management system of the prior art.

Fig. 3 is a diagram illustrating a computer system as a preferred embodiment of the present invention.

Fig. 4 is a diagram illustrating a configuration of a storage monitoring apparatus.

Fig. 5 is a diagram illustrating relationship among a volume, a RAID group and a hard disk drive of the storage apparatus.

Fig. 6 is a diagram illustrating volume configuration information of the storage monitoring apparatus.

Fig. 7 is a diagram illustrating a configuration of a switch monitoring apparatus.

Fig. 8 is a diagram illustrating apparatus connecting information of the switch monitoring apparatus.

Fig. 9 is a diagram illustrating a configuration of a computer monitoring apparatus.

Fig. 10 is a diagram illustrating relationship between a volume of the computer monitoring apparatus and a logical volume thereof.

Fig. 11 is a diagram illustrating logical volume configuration information, logical volume free space information and database table allocation information of the computer monitoring apparatus.

Fig. 12 is a configuration diagram of a management apparatus.

Fig. 13 is a configuration diagram of an integrated management apparatus.

Fig. 14 is a diagram illustrating mapping information in a connecting information comprehensive control module.

Fig. 15 is a flowchart illustrating operation of the connecting information comprehensive control module.

Fig. 16 is a flowchart illustrating operation of a performance monitoring comprehensive control module.

Fig. 17 is a flowchart illustrating operation of a volume assignment comprehensive control module.

Fig. 18 is a flowchart illustrating operation in the comprehensive operations of the volume assignment comprehensive control module and a logical volume monitoring comprehensive control module.

Fig. 19 is a flowchart illustrating operation of a database backup comprehensive control module.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[First Embodiment]

[0016] Fig. 1 is an architecture diagram of an embodiment of the present invention. An operation management system in an embodiment of the present invention respectively provides interfaces 11 to three modules for monitoring and controlling a storage apparatus, a connecting apparatus and a computer, namely, a storage monitoring apparatus 100, a switch monitoring apparatus 200 and a computer monitoring apparatus 300 and then connects these interfaces to a first communication bus 10. A comprehensive control module 400 to realize comprehensive monitoring and controlling operations using the storage monitoring apparatus 100, switch monitoring apparatus 200 and computer monitoring apparatus 300 is given an interface 11 and is connected to the first communication bus 10. The comprehensive control module 400 is moreover given an interface 21 and is connected to a second communication bus 20. In addition, the comprehensive control module 400 realizes comprehensive processes with the other comprehensive control module 400 through connection with the second communication bus 20 via the interface 21. Moreover, an integrated control module 500 which realizes comprehensive monitoring and controlling operations using a plurality of comprehensive control modules 400 is also provided with the interface 21 and is connected to the second communication bus 20.

[0017] An example of configuration of a computer system in which the architecture of an embodiment of the present invention illustrated in Fig. 1 is mapped to the computer system is illustrated in Fig. 3. The computer system of Fig. 3 is configured with four storage apparatuses 101 to 104, two connecting apparatuses (FC switch 201 and IP switch 202) and four computers 301 to 304. The FC switch 201 is connected to the storage apparatuses 101, 102 and computers 301, 302 using a fiber channel 208. The apparatus connected to the FC switch 201 includes a fiber channel port for connection to the fiber channel. The IP switch 202 is connected to the storage apparatuses 103, 104 and computers 303, 304 using the Ethernet 209. The apparatus connected to the IP switch 202 includes the Ethernet port for connection to the Ethernet.

[0018] The storage apparatuses 103 and 104 are respectively provided with the storage monitoring apparatus 100. The storage apparatuses 101 and 102 is respectively provided with the storage monitoring apparatuses 191 and 192 which are inherent to the storage apparatus. The storage apparatuses 103 and 104 are respectively provided with a monitoring and conversion apparatus 190 which is provided with the storage monitoring apparatus 100 for the storage apparatuses 101 and 102. The FC switch 201 and IP switch 202 are respectively provided with the switch monitoring apparatus

200. The computers 301 to 304 are respectively provided with the computer monitoring apparatus 300. In Fig. 3, the switch monitoring apparatus 200 and computer monitoring apparatus 300 are described as the apparatuses to be provided for respective apparatuses but these may also be realized, like the storage apparatuses 101 and 102, by providing the monitoring and conversion apparatus. Moreover, the present invention can also be realized under the condition that a monitoring and conversion apparatus operates as the monitoring and conversion apparatus for a plurality of apparatuses, for example, the storage apparatus and connecting apparatus, storage apparatus and computer, connecting apparatus and computer and storage apparatus, connecting apparatus and computer, or the like.

[0019] The storage monitoring apparatus 100, switch monitoring apparatus 200 and computer monitoring apparatus 300 are respectively connected with the first communication bus 12 and are also connected to the three management apparatuses 401 to 403. The management apparatuses 401 to 403 are respectively provided with comprehensive control module 400. In Fig. 3, three management apparatuses are respectively provided with the comprehensive control module 400 but the present invention can also be realized by providing a plurality of comprehensive control modules 400 to only one management apparatus.

[0020] Three comprehensive modules are connected with the second communication bus 22 and also connected to a management apparatus 501. The management apparatus 501 is provided with the integrated control module 500.

[0021] In an embodiment of the present invention, it is assumed that the first communication bus and the second communication bus use the Ethernet based on the Internet protocol.

[0022] Moreover, the CIM Operation over HTTP/XML is assumed as the first communication bus. Therefore, the storage monitoring apparatus 100, connection module monitoring apparatus 200 and computer monitoring apparatus 300 include the CIMOM (CIM Object Manager) having the apparatus information and function expressed with the data format specified with the CIM (Common Information Model). The comprehensive control module 400 obtains the information specified by the CIM from the storage monitoring apparatus 100, connection module monitoring apparatus 200 and computer monitoring apparatus 300 and realizes monitoring and controlling operations by calling the function (method) specified by the CIM. As the second communication bus, the SOAP is assumed. The SOAP realizes calling of the function using the XML/HTTP. Mutual functions may be used with the uniform procedures by utilizing the SOAP among the comprehensive control modules 400 and between the comprehensive control module 400 and integrated control module 500.

[0023] The storage monitoring apparatus 100, connection module monitoring apparatus 200, computer

monitoring apparatus 300, comprehensive control module 400 and integrated control module 500 can easily realize monitoring and controlling operations without dependence on the combination thereof by utilizing the standard technology (CIM Operation XML/HTTP and SOAP in this embodiment) for the first communication bus and the second communication bus. A non-standard technology may be, of course, used but it also gives difficulty in mutual connection capability which is excellent effect of the present invention.

[0024] Here, the storage monitoring apparatus 100 will be described. The storage monitoring apparatus 100 may be provided to a storage apparatus itself or may be realized by disposition to the monitoring and conversion apparatus 190 with connection to the storage apparatus. Information and function required for monitoring and controlling a storage apparatus is mounted, using the CIM, to the storage monitoring apparatus 100. In this embodiment, as illustrated in Fig. 4, a volume creation function 110 and a replication volume control function 111 are provided as the minimum necessary functions of this embodiment. Moreover, as the minimum necessary information of this embodiment, volume configuration information 112, volume and RAID group performance information 113 are prepared. The storage monitoring apparatus 100 offers the function and information described above to the comprehensive control module 400 via the interface 11. The comprehensive control module 400 can realize monitoring and controlling processes with the common procedures without relation to the apparatus by utilizing the interface 11 corresponding to the first communication bus 12.

[0025] The volume creation function 110 is provided to create a volume of the capacity instructed from the comprehensive control module 400 in the storage apparatus. Moreover, when creation of replication volume is instructed from a management module, a volume consisting of a pair of primary volume and secondary volume can be created. In the primary volume and secondary volume provided as a pair of volumes, when such pair volumes are maintained, the secondary volume always holds a replication of the primary volume.

[0026] The replication volume control function 111 controls a pair of primary volume and secondary volume with the volume creation function. This function includes a split control for separating the primary volume and secondary volume and a resynchronization control for pairing again (wherein data of the primary volume and secondary volume are matched) the separated primary volume and secondary volume.

[0027] The volume creation function 110 and replication volume control function 111 can be realized when the control unit 120 of the storage monitoring apparatus 100 executes a program stored in the storage unit 130 of the storage monitoring apparatus 100. This program is recorded in a storage medium such as a CD-ROM or the like and is then stored in a magnetic disk or the like. Thereafter, this program is loaded to a memory for ex-

ecution. As a medium for recording the program, the other media except for the CD-ROM may be used. Moreover, this program may be installed to a computer from the relevant storage medium and may also be used by making access to the relevant storage medium through the network.

[0028] A couple of characteristic information of the volume configuration information 112 and the volume and RAID group performance information 113 are prepared as the information offered to the comprehensive control module 400 from the storage monitoring apparatus 100.

[0029] Fig. 5 is a schematic diagram of volume configuration information 112 stored in the storage unit 120 of the storage monitoring apparatus 100. The volume configuration information 112 illustrates correspondence among the volumes, RAID groups and hard disk drives. As illustrated in Fig. 5, in the storage apparatus utilizing the RAID technology, the RAID group to which the volumes provided for the computer (five volumes 161 to 165 in Fig. 5) belong, the number of hard disks included in the respective RAID groups and the algorithm of RAID which is used for management are determined by the setting (control) in the storage apparatus. The volume and RAID group performance information 113 indicates the performance (throughput, number of times of read/write operations per unit time and response time or the like) in unit of each hard disk, each RAID group and each volume in the storage apparatus.

[0030] The switch monitoring module 200 will be explained. This switch monitoring module 200 may be provided to a connecting apparatus itself or may be realized through connection with the connecting apparatus by providing the monitoring and conversion apparatus. Information and function required for monitoring and controlling processes are mounted to the switch monitoring module 200 by utilizing the CIM. In this embodiment, as illustrated in Fig. 7, an access security control function 210 is also provided as the minimum necessary function for this embodiment.

[0031] The access security control function 210 can be realized when the control unit 220 of the switch monitoring module 200 executes a program stored in the storage unit 230 of the switch monitoring module 200. This program is recorded to a recording medium such as CD-ROM or the like and is then stored to a magnetic disk or the like and finally loaded to the memory for execution. Moreover, as a medium for recording the program, a storage medium except for the CD-ROM may be used. In addition, this program may be installed to the computer from the relevant storage medium or may be used by making access to the relevant storage medium through the network.

[0032] Moreover, as the minimum necessary information in this embodiment, apparatus connecting information 211 is provided. The switch monitoring module 200 offers the function and information described above to the comprehensive control module 400 via the interface

11. The comprehensive control module 400 can realize monitoring and controlling processes in the common procedures without dependence on the apparatus by utilizing the interface 11 corresponding to the first communication bus 10.

[0033] The access security control function 210 corresponds to a zoning function in the FC switch 201 and a VLAN (Virtual LAN) function in the IP switch 202. This function is used for setting up the connections among the particular apparatuses connected to the FC switch and IP switch. As the characteristic information offered to the comprehensive control module 400 by the switch monitoring module 200, the apparatus connecting information 211 is provided. In the case of the apparatus configuration illustrated in Fig. 1, the apparatus connecting information of the FC switch 201 as the connecting apparatus and the apparatus connecting information of the IP switch 202 are expressed, for example, as illustrated in Fig. 8. In the case of Fig. 8, it is understood that the FC switch 201 is connected with the storage apparatuses 101, 102 and computers 301, 302 and the storage apparatus 101 and computer 301 belong to the ZONE1, while the storage apparatus 102 and computer 302 belong to the ZONE2. It is inhibited that the computer of a certain ZONE uses the storage apparatus in different ZONE. In the same manner, it can also be understood that the IP switch 202 is connected with the storage apparatuses 103, 104 and the computers 303, 304. Since the access security is not set up (controlled), the computers 303 and 304 can apparently use both storage apparatuses 103 and 104.

[0034] The computer monitoring module 300 will then be described below. The computer monitoring module 300 may be provided to the computer itself or may be realized with connection to the computer by providing a monitoring and conversion apparatus. Information and function which are required for monitoring and controlling processes of the computer are mounted to the computer monitoring module 300 using the CIM. This embodiment will be described under the assumption that a database application and a backup application are executed on the computer. Therefore, as illustrated in Fig. 9, a volume mount function 310, a logical volume creation function 311, a database suspension function 312 and a backup control function 313 are provided as the minimum necessary functions of this embodiment.

[0035] The volume mount function 310, logical volume creation function 311, database suspension function 312 and backup control function 313 are realized when the control unit 320 of the computer monitoring module 300 executes a program stored in the storage unit 330 of the computer monitoring module 300. This program is recorded to a recording medium such as CD-ROM, stored to a magnetic disk and is finally loaded to a memory for execution. Moreover, as a medium for recording the program, the other storage medium except for the CD-ROM may be used. In addition, the program may be installed to a computer from the relevant

storage medium or may be used by making access to the relevant storage medium through the network.

[0036] Moreover, as the minimum necessary information in this embodiment, logical volume configuration information 315, logical volume free space information 316, logical volume performance information 317 and database table allocation information 318 are prepared. The computer monitoring module 300 provides the function and information described above to the comprehensive control module 400 via the interface 11. The comprehensive control module 400 executes monitoring and controlling processes in the standard procedures without dependence on the apparatus by utilizing the interface 11 corresponding to the first communication bus 10.

[0037] The volume mount function 311 is provided to use, on the computer, the volume of the storage apparatus detected from the computer. The logical volume creation function 312 is provided to create a logical volume by combining a plurality of volumes in the volume which can be used on the computer with the volume mount function 311 and to create a plurality of volumes by dividing a volume. The application on the computer executes the processes by writing and reading data to and from this logical volume. In the computer system of Fig. 3 of this embodiment, the storage apparatus 101 can be detected from the computer 301 and thereby five volumes 161 to 165 illustrated in Fig. 5 can be mounted for use. In this embodiment, the five volumes can be combined and divided as illustrated in Fig. 10 from the computer 101 for use as the logical volume. The database suspension function 312 is the control function for the database application and is provided to switch the database to the online backup mode. When the database online backup mode is selected, the database can be suspended in this timing and thereby the database backup can be obtained during operation of database. The backup control function 313 is the control function for the backup application and is provided to instruct a tape device (not illustrated) to prepare for the backup of the designated logical volume. As the characteristic information provided by the computer monitoring apparatus 300 for the comprehensive control module 400, four information pieces of the logical volume configuration information 315, logical volume free space information 316, logical volume performance information 317 and database table allocation information 318 are provided. The logical volume configuration information 315 indicates a configuration of the logical volume which is used by the volume of storage apparatus and computer illustrated in Fig. 10. In Fig. 11, examples of logical volume free space information 316 and database table allocation information 318 in this embodiment are illustrated. The logical volume performance information 318 indicates the performance in unit of each logical volume (through put, number of times of read/write operations per unit time and response time or the like) in the computer.

[0038] Fig. 12 is a configuration diagram of a management apparatus. The management apparatuses 401 to 403 respectively comprise an interface 411 which realizes transmission and reception of information required for management depending on the standard protocol among the storage apparatuses 101, 102, 103, 104, computers 301, 302, 303, 304 and connecting apparatuses 201, 201 and among the integrated management apparatuses 501, 502, 503, a storage unit (memory) 420 for storing various information pieces received via the interface 411 and program and data executed by the control unit 430, an input/output interface 450 for connecting a display 490, a keyboard 492 and a mouse 494 and the control unit 430 to realize a comprehensive control module 400. Moreover, the interface 411 may transmit and receive the information required for management depending on the standard protocol among a plurality of management apparatuses 401, 402, 403.

[0039] The comprehensive control module 400 realizes the management function when the control unit 430 executes the program stored in the control unit (memory) 420. This program is recorded to a recording medium such as CD-ROM, stored to a magnetic disk or the like and thereafter loaded to the memory for execution. Moreover, a medium for recording the program may be a recording medium other than the CD-ROM. In addition, the program may be installed to the computer from the relevant storage medium or may be used by making access to the relevant medium through the network.

[0040] The comprehensive control module 400 is a software module to realize the comprehensive functions by combining the storage monitoring apparatus 100, switch monitoring apparatus 200 and computer monitoring apparatus 300. This comprehensive control module 400 executes the process on the management apparatuses (401 to 403). In this embodiment, four comprehensive control modules of the connecting information comprehensive control module, performance monitoring comprehensive control module, volume assignment comprehensive control module and database backup comprehensive module will be explained as the practical embodiments of the comprehensive control module 400.

[0041] The connecting information comprehensive control module obtains necessary information from the storage monitoring apparatus 100, switch monitoring apparatus 200 and computer monitoring apparatus 300 via the interface 11 and first communication bus and creates a mapping up to the RAID group of storage apparatus from a table used by the database application on the computer. The processes will be described with reference to the flowchart of Fig. 15.

[0042] First, apparatus connecting information 212 is obtained (1501) from the switch monitoring apparatus 200 of the connecting apparatuses (FC switch 201 and IP switch 202 in this embodiment). Even if the FC switch 201 and IP switch 202 are apparatuses of different vendors, since the switch monitoring apparatus 200 in-

cludes the interface 11 for the first communication bus 12, the apparatus connecting information 212 can be obtained with the standard procedures without dependence on difference of apparatuses. Next, the connecting information comprehensive control module obtains volume configuration information 112 from the storage monitoring apparatus 100 (1503). In the configuration of Fig. 3, the volume configuration information 112 of the storage apparatuses 103, 104 is obtained from the storage monitoring apparatus 100 of respective storage apparatuses, while the volume configuration information of the storage apparatuses 101, 102 is obtained from the storage monitoring apparatus 100 of the monitoring and converting apparatus 190. Next, the connecting information comprehensive control module obtains logical volume configuration information 315 from the computer monitoring apparatus 300 (1505). Moreover, this module also obtains database table allocation information 318 from the computer monitoring apparatus 300 (1507). The connecting information comprehensive control module can detect in which hard disk drive 150 of the storage apparatus the table used by the database operating on the computer is stored from the apparatus connecting information 212, volume configuration information 112, logical volume configuration information 315 and database table allocation information 318. For example, it will be detected as described below in the case of information pieces illustrated in Fig. 6, Fig. 8 and Fig. 11. The computer 301 and storage apparatus 101 belong to the same ZONE1. The "ACCOUNT" table is stored in the LBAs (Logical Block Addresses) 100 to 500 of a logical drive 363 and this logical drive 363 is formed of a couple of volumes 163 and 164 of the storage apparatus 101. The volumes 163 and 164 form a pair-volume and the volume 163 belongs to the RAID group 151, while the RAID group 151 is the RAID5 which is configured with three units of hard disk drive. The volume 164 belongs to the RAID group 152 and the RAID group 152 is the RAID5 configured with three units hard disk drive. The "TEMP" table is stored in the LBAs 0 to 200 of the logical drive 364 and the logical drive 364 is configured with two volumes 162, 165 of the storage apparatus 101. The volumes 162 and 165 are volumes coupled with the computer 301. The volume 163 belongs to the RAID group 151 and the RAID group 151 is the RAID5 configured with three units of hard disk drive. The volume 164 belongs to the RAID group 152 and the RAID group 152 is the RAID5 configured with three units of hard disk drive. Here, it can be understood that the "ACCOUNT" table and the "TEMP" table are allocated on different logical volumes 363 and 364 on the computer 301 but the same RAID group (151 and 152) is used within the storage apparatus 101.

[0043] The connecting information comprehensive control module offers the mapping information created by the procedures described above (1509) to the other comprehensive control module 400 and integrated control module 500 via the second communication bus 22

and interface 21 (1513) when the other control module or integrated control module has issued a request to obtain the mapping information (1511).

[0044] As described above, the connecting information comprehensive control module can provide mapping information to the other comprehensive module 400 and integrated control module 500 via the second communication bus (SOAT in the case of this embodiment) by obtaining information in the procedures described above (CIM Operation over HTTP/XML in the case of this embodiment) from the storage apparatus, connecting apparatus and computer via the first communication bus and then creating the mapping information from this information. Since the connecting information comprehensive control module not only can obtain the information via the first communication bus without dependence on difference of apparatus but also provide the information via the second communication bus by specifying the first communication bus and the second communication bus, the other comprehensive control module is capable of obtaining the mapping information from the connecting information comprehensive control module and then using this information in place of generating such mapping information. Moreover, all comprehensive control modules can realize matching of the mapping information in the comprehensive control modules because these modules use the mapping information provided by the connecting information comprehensive control module. In addition, since the monitoring and controlling function can be realized with the standard procedures by specifying the first communication bus and the second communication bus, replacement can be realized easily even when a plurality of connecting information comprehensive modules of different functions are prepared.

[0045] The performance monitoring comprehensive control module is provided to search a bottleneck of performance in the computer system. This search process will be described with reference to the flowchart of Fig. 16.

[0046] First, the performance monitoring comprehensive control module obtains the mapping information from the connecting information comprehensive control module via the interface 21 and second communication bus 20 (1601). The performance monitoring comprehensive control module displays a configuration diagram illustrated in Fig. 12 to the display 490 of the management apparatus based on the mapping information obtained (1603). When an administrator for operation management of computer system selects a "LOG" table (instruction by the click from an input module such as mouse) on the display module (1605), the performance monitoring comprehensive control module obtains performance information of the logical volume 361 in relation to the "LOG" table from the computer monitoring apparatus 300 via the interface 11 and first communication bus 10 (1607) and also obtains the performance information of the volume 161 and RAID group 151 from

the storage monitoring apparatus 300 via the interface 11 and first communication bus 10 (1609) and then displays the performance information obtained to the display module provided in the management apparatus (1611). An administrator is capable of detecting an area where a load is heavy and determining a measure to be taken from the performance information displayed on the display module provided in the management apparatus.

[0047] The volume assignment comprehensive control module has a function to newly create a volume. This process will be explained with reference to the flowchart of Fig. 17.

[0048] An administrator can input an instruction to create a volume to the particular computer using the display 490, keyboard 491 and mouse 492 provided to the management apparatus. The volume assignment comprehensive control module obtains (1703), when it is instructed to create a volume to the particular computer of management apparatus (1701), connecting information 211 from the switch monitoring apparatus 200 via the interface 11 and first communication bus 10 and identifies (1705) the storage apparatus to be available from the computer in which a volume must be assigned. When a plurality of storage apparatuses are available and a plurality of RAID groups may be used even in the storage apparatus, the candidates are displayed on the display module provided in the management apparatus (1707) for the selection by an administrator using the display 490 (1709).

[0049] Next, the volume creation function 110 of the storage monitoring apparatus 100 is called via the interface 11 and first communication bus 10 in order to create a volume (1711). If necessary, the access security control function 210 of the switch monitoring apparatus 200 is called via the interface 11 and first communication bus 10 to control (set) access security (zoning in the case of FC switch, VLAN in the case of the IP switch) via the interface 11 and first communication bus 10 in order to use the volume created only from the particular computer (1713). Next, the volume mount function 310 of the computer monitoring apparatus 300 is called via the interface 11 and first communication bus 10 to mount the volume created to the storage apparatus (1715) and the logical volume creation function 311 is also called to use the volume mounted as the logical volume (1717).

[0050] The logical volume monitoring comprehensive control module has a function to monitor the logical volumes of the computer and detect logical volumes which exhibit lack of free capacity. When the logical volume monitoring comprehensive control module finds a logical volume which exhibits lack of free space (in practical, when capacity becomes lower than the preset threshold value) for the previously registered comprehensive control module 400, it notifies this condition via the interface 21 and second communication bus 22. The function to additionally assign the volume can be realized for the logical volume which exhibits lack of free space through

comprehensive process of the logical volume monitoring comprehensive control module and volume assignment comprehensive control module described above. These processes will be described with reference to the flowchart of Fig. 18.

[0051] The volume assignment comprehensive control module previously registers the monitoring process of free space of logical volume to the logical volume monitoring comprehensive control module via the interface 21 and second communication bus 22 (1801). Accordingly, when a volume which seems to exhibit lack of free space is detected, the logical volume monitoring comprehensive control module notifies this condition to the volume assignment comprehensive control module. The logical volume monitoring comprehensive control module obtains logical volume free space information 316 from the computer monitoring apparatus 300 via the interface 11 and first communication bus 12 with an interval of constant period in order to monitor the free space of logical volume (1803). When the free space of volume becomes lower than the preset threshold value (1805), the volume assignment comprehensive control module notifies that a volume seems to exhibit lack of free space thereof to the logical volume monitoring comprehensive control module to the logical volume monitoring comprehensive control module via the interface 21 and first communication bus 22 (1807). The logical volume monitoring comprehensive control module calls, upon reception of this notification, the volume creation function 110 of the storage monitoring apparatus 100 to create a volume (1809). In order to use the created volume only from particular computer, if necessary, the access security control function 210 of the switch monitoring apparatus 200 is called and then controlled (1811) via the interface 11 and first communication bus 12.

[0052] Next, the volume mount function 310 of the computer monitoring apparatus 300 is called via the interface 11 and first communication bus 12 to mount a created volume to the storage apparatus (1813) and the logical volume creation function 311 is called to add the mounted volume to the logical volume which exhibits lack of free space (1815) in order to prevent lack of free space.

[0053] As described above, the logical volume monitoring comprehensive control module can realize monitoring of free space by monitoring the free space of logical volume via the first communication bus and notifying the result of monitoring to the other comprehensive control module via the second communication bus. For example, in the example described above, the volume assignment comprehensive control module can also realize monitoring of free space through comprehensive process with the logical volume monitoring comprehensive control module via the second communication bus even without monitoring of the free space via the first communication bus. Since the logical volume monitoring comprehensive control module can be realized with the standard sequence by specifying the first and sec-

ond communication buses, replacement can easily be realized even when several logical volume monitoring comprehensive control modules and volume assignment comprehensive control modules having different functions are used.

[0054] An integrated control module through comprehensive operation of the volume assignment comprehensive control module and performance monitoring comprehensive control module will then be described. Performance information in relation to selection of the volume creation destination can also be displayed together by integrated management through the comprehensive operation of execution result of monitoring by these two modules.

[0055] Fig. 13 is a configuration diagram of an integrated management apparatus. The integrated management apparatus 501 comprises an interface 511 which enables transmission and reception of information required for management depending on the standard protocol among the management apparatuses 401, 402, 403, a storage unit 520 for storing various information pieces received via the interface 511 and program, data executed by the control unit 530, an input/output interface 450 for connecting a display 590, a keyboard 592 and a mouse 594 and a control unit 530 for realizing the integrated management module 500. Moreover, the interface 511 may also be permitted to transmit and receive the information required for management depending on the standard protocol among the integrated management apparatuses when a plurality of management apparatuses are used.

[0056] The integrated management module 500 can realize the integrated management function when the control unit 530 executes the program stored in the storage unit 520. This program is recorded to a recording medium such as CD-ROM, stored in a magnetic disk or the like and finally loaded to a memory for execution. Moreover, as the medium for recording the program, the other storage media except for CD-ROM may be used. In addition, this program may be installed to the computer from the relevant storage medium through the network. An administrator is capable of inputting an instruction to create a volume to the particular computer using the display 490, keyboard 491 or mouse 492 provided to the management apparatus. The integrated management module 500 instructs the volume assignment comprehensive control module, when it is instructed to create a volume to the particular computer of the management apparatus, to create a new volume to this computer via the interface 22 and second communication bus. Here, when a plurality of storage apparatuses may be used and a plurality of RAID groups may be used even in the storage apparatus, a list of candidates is returned. Next, the integrated management module 500 displays the performance information of the RAID group listed as the candidate of new volume creation from the performance monitoring comprehensive control module. Thereby, an administrator can judge a degree of influence of

the other volumes on the volume to be created.

[0057] As described above, the integrated control module may be realized as a software module which is not specified by the first communication bus but only by the second communication bus.

[0058] The database backup comprehensive control module offers a function to realize backup of database while this database is used.

[0059] An administrator can input an instruction for backup of database table using the display 490, and keyboard 491 or mouse 492 provided in the management apparatus. The database backup comprehensive control module creates a backup of the table when it is instructed to create a backup of the database table. The process will be described with reference to the flowchart of Fig. 19.

[0060] The database backup comprehensive control module obtains mapping information from the connecting information comprehensive control module via the interface 21 and second communication bus 22 (1901). The database backup comprehensive control means (module) displays a configuration diagram as illustrated in Fig. 12 to the display module provided in the management module based on the mapping information obtained (1903). For example, when an administrator who executes operation management of the computer system instructs creation of a backup of the "ACCOUNT" table (1905), the database backup comprehensive control module instructs the database suspension function 312 of the computer monitoring apparatus 300 to switch the database application to the online backup mode via the interface 11 and first communication bus 12 (1907). Next, the database backup comprehensive control module instructs the replication volume control function 111 of the storage monitoring apparatus 100 to split the volumes 163 and 164 via the interface 11 and first communication bus 12 (1909). With these two procedures, the database table suspended when the split is instructed is stored in the volume 164. Next, the database backup comprehensive control module instructs the database suspension function 312 of the computer monitoring apparatus 300 to complete the online backup mode of the database application (1911). In addition, the database backup comprehensive control module instructs the backup control function 313 of the computer monitoring apparatus 300 to create a backup of the volume 164 to a tape device (not illustrated) via the interface 11 and first communication bus 12. Upon completion of the backup process with the backup application, the database backup comprehensive control module instructs the replication volume control function 111 of the storage monitoring apparatus 100 to re-synchronize the volumes 163 and 164 via the interface 11 and first communication bus 12 (1915).

[0061] As described above, since the database backup comprehensive control module can have the mapping information obtained via the second communication bus to instruct the backup starting from the data-

base table to an administrator by specifying the first communication bus and the second communication bus, to execute the backup operation for the table to which the backup is instructed, and moreover to realize the backup operation with the standard procedures for the table to which the backup is instructed by specifying the first communication bus and the second communication bus, replacement can be realized easily even when a plurality of database backup comprehensive modules having different functions are provided.

[0062] As a function of the integrated control module, a standard information storage module (standard repository) 590 may be provided. The standard information storage module 590 is provided for integrated management of the mapping information created by the connecting information comprehensive control module, performance information collected by the performance monitoring comprehensive module and free space information of logical volumes collected by the volume assignment comprehensive control module. Since each comprehensive module 400 previously stores the collected information to the standard information storage module 590 via the interface 21 and second communication bus 20, the integrated control module 500 executes the process without sending of any inquiry to each comprehensive control module 400. The standard information storage module 590 can realize its function when the control unit 530 executes the program stored in the storage unit 520. This program is assumed to be executed after it is recorded to a recording medium such as CD-ROM, then stored to a magnetic disk or the like and then loaded to a memory. Moreover, this program may be recorded to the other media except for the CD-ROM. In addition, this program may be installed to a computer from the relevant storage media and also may be used by making access to the relevant storage media through the network.

[0063] The operation management system of the present invention can assure mutual connection capability among operation management applications by simultaneously specifying two interfaces of the first interface for the devices as the operation management object and the second interface provided with the operation management application which can be realized using the first interface.

Claims

1. An operation management system comprising:

- a computer,
- a storage apparatus for storing write information or read information to or from said computer,
- a connecting apparatus for connecting said computer and said storage apparatus, and
- a management apparatus for management of

said computer, said storage apparatus and said connecting apparatus,

wherein said management apparatus comprises:

a control unit for realizing the management function through comprehensive process of characteristic information of said storage apparatus, characteristic information of said connecting apparatus and characteristic information of said computer, and
an interface for receiving said characteristic information from said storage apparatus, said connecting apparatus or said computer depending on the standard protocol among said management apparatus, said storage apparatus, said connecting apparatus and said computer.

2. An operation management system comprising:

a computer,
a storage apparatus for storing write information or read information to or from said computer,
a connecting apparatus for connecting said computer and said storage apparatus, and
a management apparatus for management of said computer, said storage apparatus and connecting apparatus,

wherein said management apparatus comprises:

a control unit for realizing a management function through comprehensive process of characteristic information of said storage apparatus, characteristic information of said connecting apparatus and characteristic information of said computer, wherein said operation management system further comprises an integrated management apparatus for integrated management based on the result of realization of a plurality of said management functions,

wherein said integrated management apparatus comprises an interface for receiving the result of realization of said management function from said management apparatus depending on the standard protocol between said management apparatus and said integrated management apparatus, and

wherein said management apparatus comprises an interface for transmitting the result of realization of said management function to said integrated management apparatus depending on said protocol.

3. An operation management system comprising:

a computer,
a storage apparatus for storing write information or read operation to or from said computer,
a connecting apparatus for connecting said computer and said storage apparatus, and
a management apparatus for management of said computer, said storage apparatus and said connecting apparatus,

wherein said management apparatus comprises:

a control unit for realizing a management function through comprehensive process of characteristic information of said storage apparatus, characteristic information of said connecting apparatus and characteristic information of said computer, and
an interface for receiving said characteristic information from said storage apparatus, said connecting apparatus or said computer depending on the standard protocol among said management apparatus, said storage apparatus, said connecting apparatus and said computer,

wherein said operation management system comprises a management apparatus for integrated management based on the result of realization of a plurality of said management functions,

wherein said integrated management apparatus comprises an interface for receiving the result of realization of said management function from said management apparatus depending on the standard protocol among said management apparatus and said integrated management apparatus, and

wherein said management apparatus comprises an interface for transmitting the result of realization of said management functions to said integrated management apparatus depending on said protocol.

4. An operation management system comprising:

a computer,
a storage apparatus for storing write information or read information to or from said computer,
a connecting apparatus for connecting said computer and said storage apparatus, and
a management apparatus for management of said computer, said storage apparatus and said connecting apparatus,

wherein said management apparatus com-

prises:

a control unit for realizing management function through comprehensive process of characteristic information of said storage apparatus, characteristic information of said connecting apparatus and characteristic information of said computer, and
an interface for transmitting and receiving the result of realization of said management function among a plurality of said management apparatus depending on the standard protocol among a plurality of said management apparatus.

5. An operation management system comprising:

a computer,
a storage apparatus for storing write information or read information to or from said computer,
a connecting apparatus for connecting said computer and said storage apparatus, and
a management apparatus for management of said computer, storage apparatus and said connecting apparatus,

wherein said management apparatus comprises:

a control unit for realizing the management function through comprehensive process of characteristic information of said storage apparatus, characteristic information of said connecting apparatus and characteristic information of said computer,

wherein said operation management system comprises a plurality of integrated management apparatus for integrated management based on the result of realization of a plurality of said management functions,

wherein said integrated management apparatus comprises an interface for transmitting and receiving the result of said integrated management among a plurality of said integrated management apparatus depending on the standard protocol among a plurality of said integrated management apparatus, and

wherein said management apparatus comprises an interface for transmitting the result of realization of said management function to said integrated management apparatus depending on said protocol.

6. The system of any preceding claim, wherein said characteristic information is expressed as CIM/XML, and said control unit interchanges said char-

acteristic information in accordance with the sequence specified with CIM Operation over XML/HTTP, and realizes the management function.

7. The system of any one of claims 1 to 5, wherein the result of realization of said management function is expressed as XML, and said integrated management apparatus interchanges said result in accordance with the sequence specified with the SOAP, and executes integrated management.

8. A management apparatus for management of a computer, a storage apparatus for storing write information or read information to or from said computer, and a connecting apparatus for connecting said computer and said storage apparatus comprising:

a control unit for realizing the management function through comprehensive process of characteristic information of said storage apparatus, characteristic information of said connecting apparatus and characteristic information of said computer, and
an interface for transmitting and receiving the result of realization of said management function among a plurality of said management apparatus depending on the standard protocol among a plurality of management apparatus.

9. A management method for management of a computer, a storage apparatus for storing write information or read information to or from said computer, and a connecting apparatus for connecting said computer and said storage apparatus comprising the steps of:

realizing the management function through comprehensive process of characteristic information of said storage apparatus, characteristic information of said connecting apparatus, and characteristic information of said computer, and
transmitting and receiving the result of realization of said management function among a plurality of said management apparatus depending on the standard protocol among a plurality of said management apparatus.

10. A management program for controlling a management apparatus for realizing the management function of a computer, a storage apparatus for storing write information or read information to or from said computer and a connecting apparatus for connecting said computer and said storage apparatus and further realizing following functions for:

realizing the management function through

comprehensive process of characteristic information of said storage apparatus, characteristic information of said connecting apparatus, and characteristic information of said computer, and

5

transmitting and receiving the result of realization of said management function among a plurality of said management apparatus depending on the standard protocol among a plurality of said management apparatus.

10

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FIG. 1

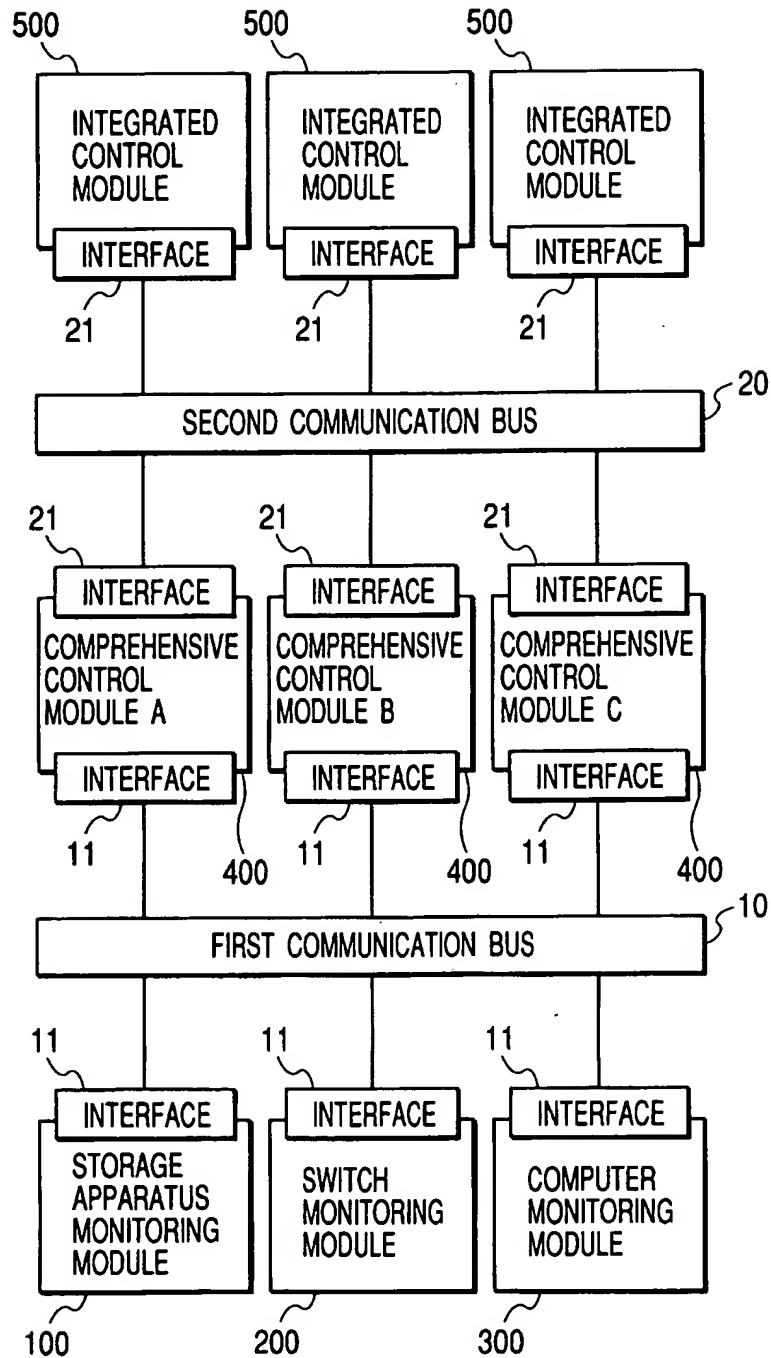


FIG. 2

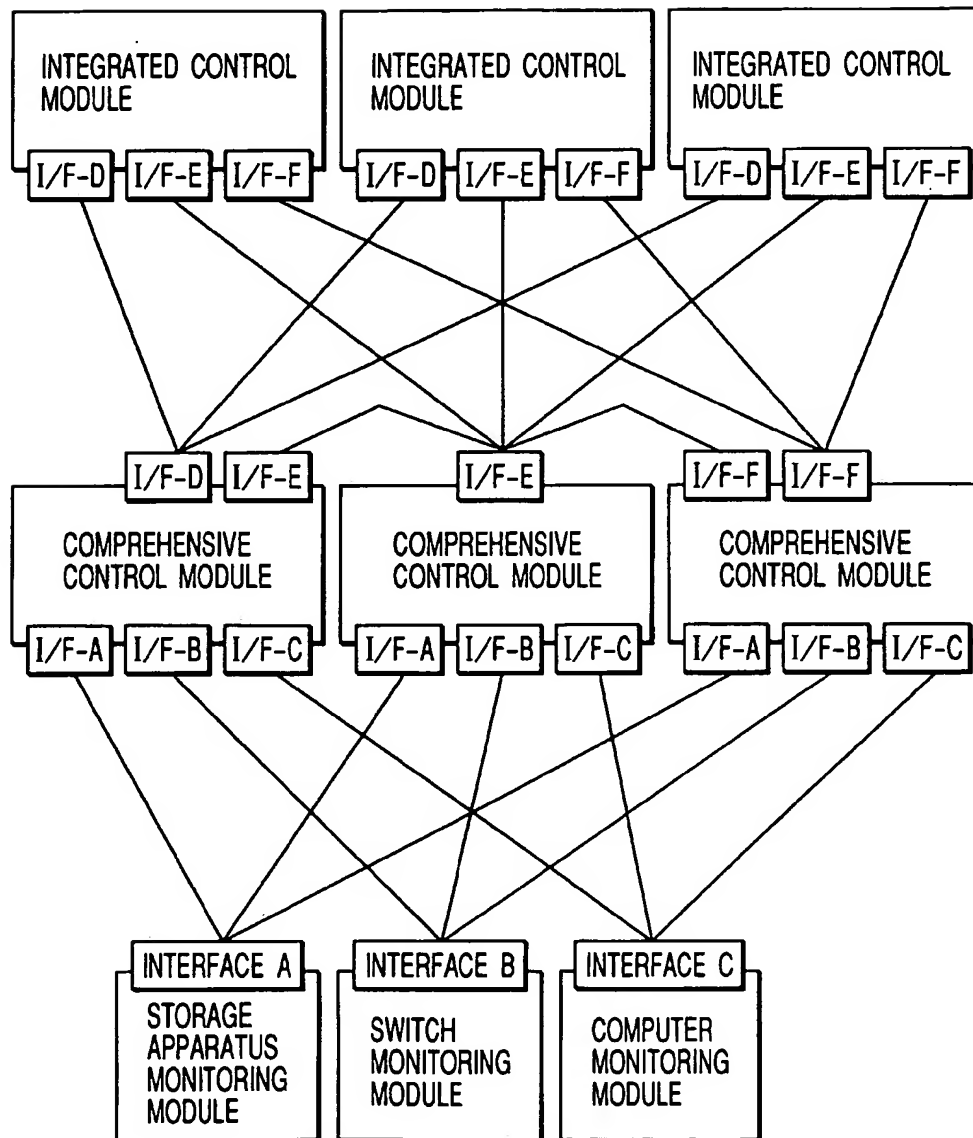


FIG. 3

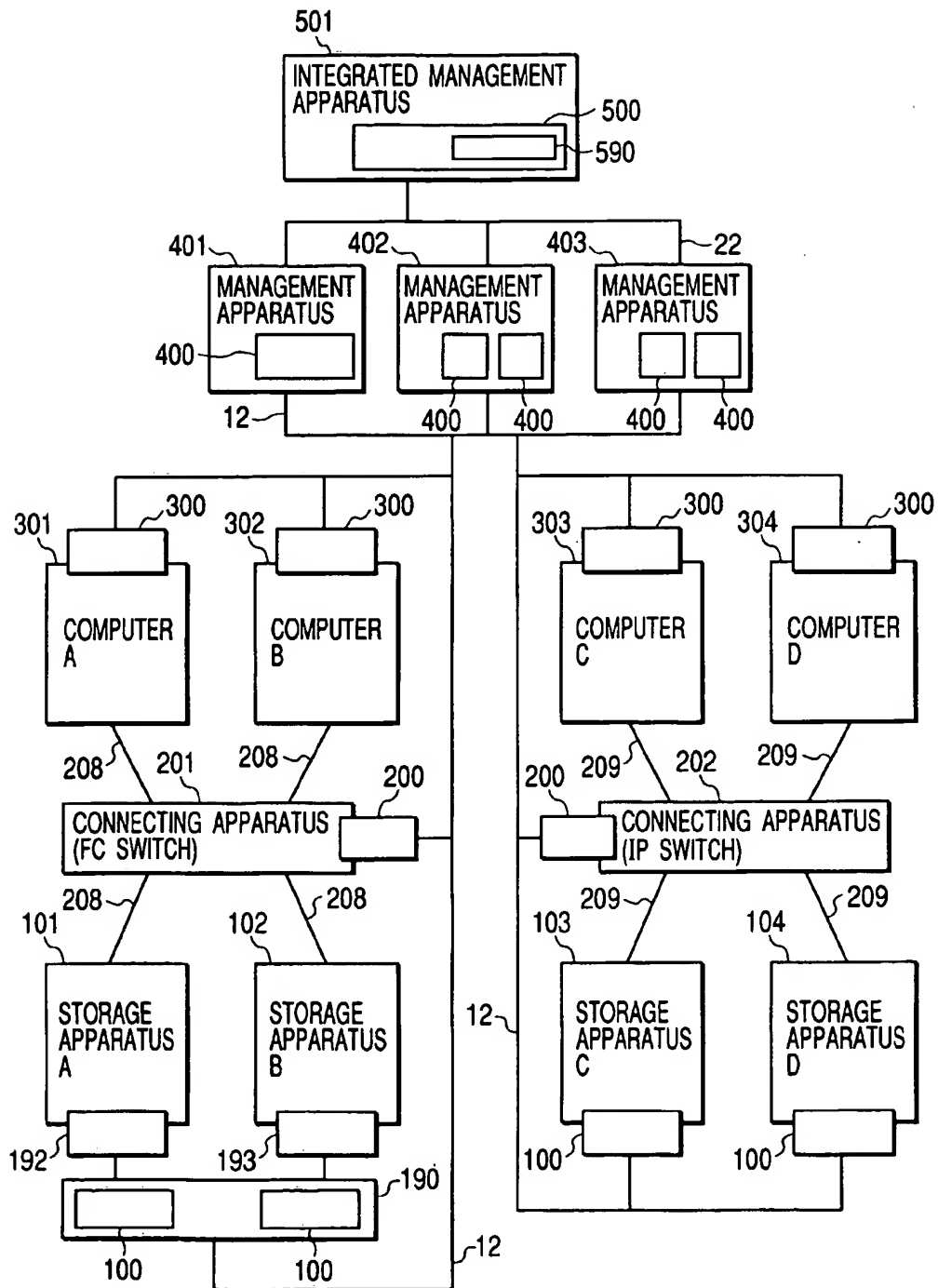


FIG. 4

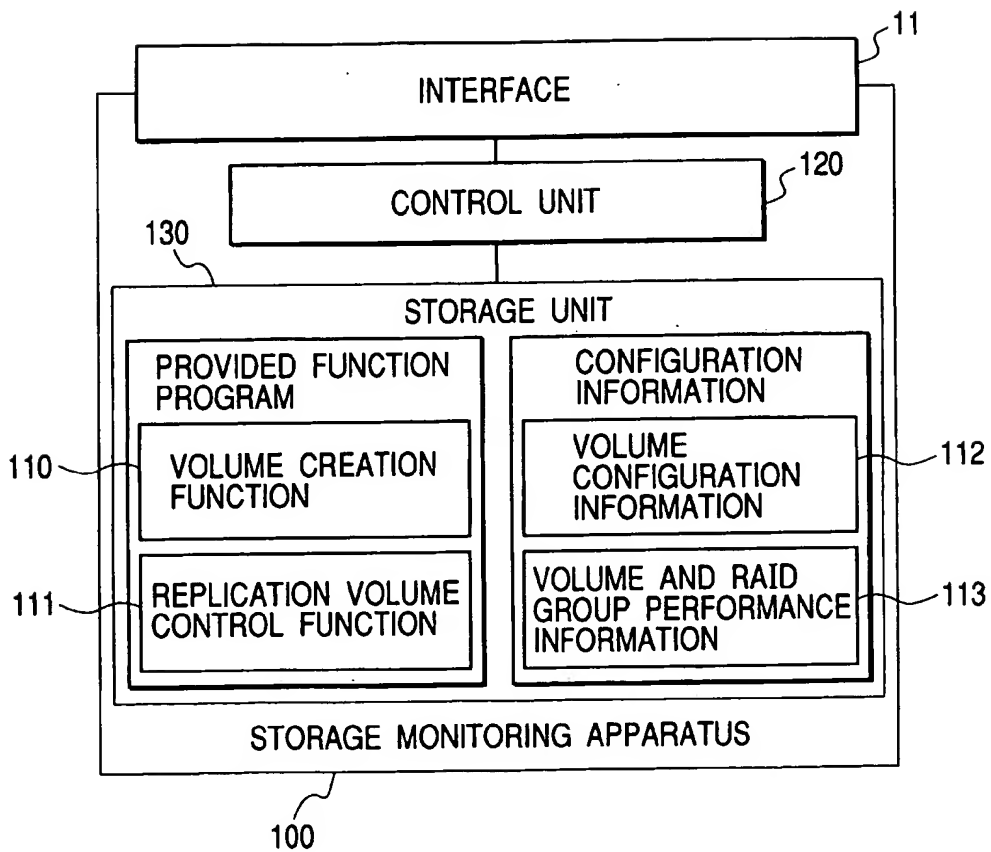
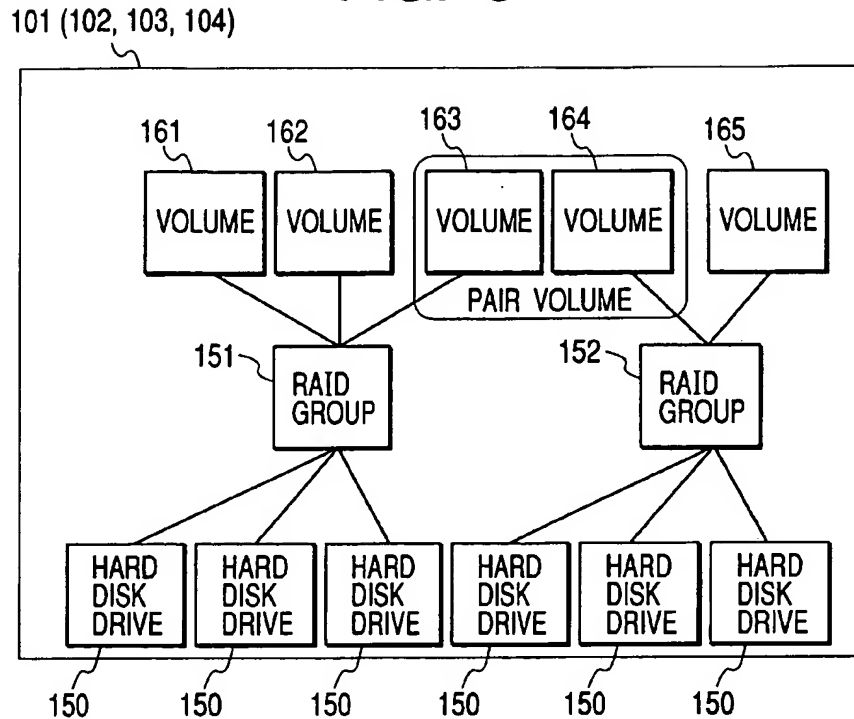


FIG. 5**FIG. 6**

112

VOLUME NO.	RAID GROUP	RAID LEVEL	NUMBER OF UNITS OF HARD DISK DRIVES FORMING A RAID GROUP	PAIRING CONDITION
161	151	RAID5	3	
162				
163				PRIMARY 164
164	152	RAID1	3	SECONDARY 163
165				

FIG. 7

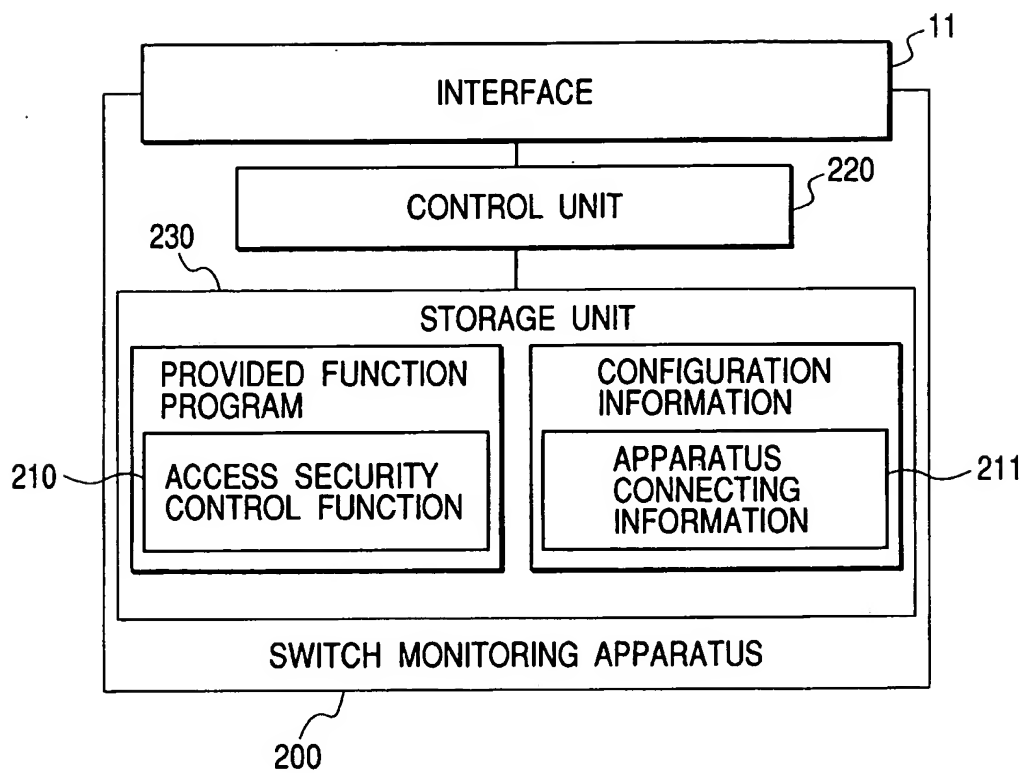


FIG. 8

APPARATUS NO.	CONNECTED APPARATUS	ACCESS SECURITY
201	101	ZONE1
	102	ZONE2
	301	ZONE1
	302	ZONE2

APPARATUS NO.	CONNECTED APPARATUS	ACCESS SECURITY
202	103	NONE
	104	NONE
	303	NONE
	304	NONE

FIG. 9

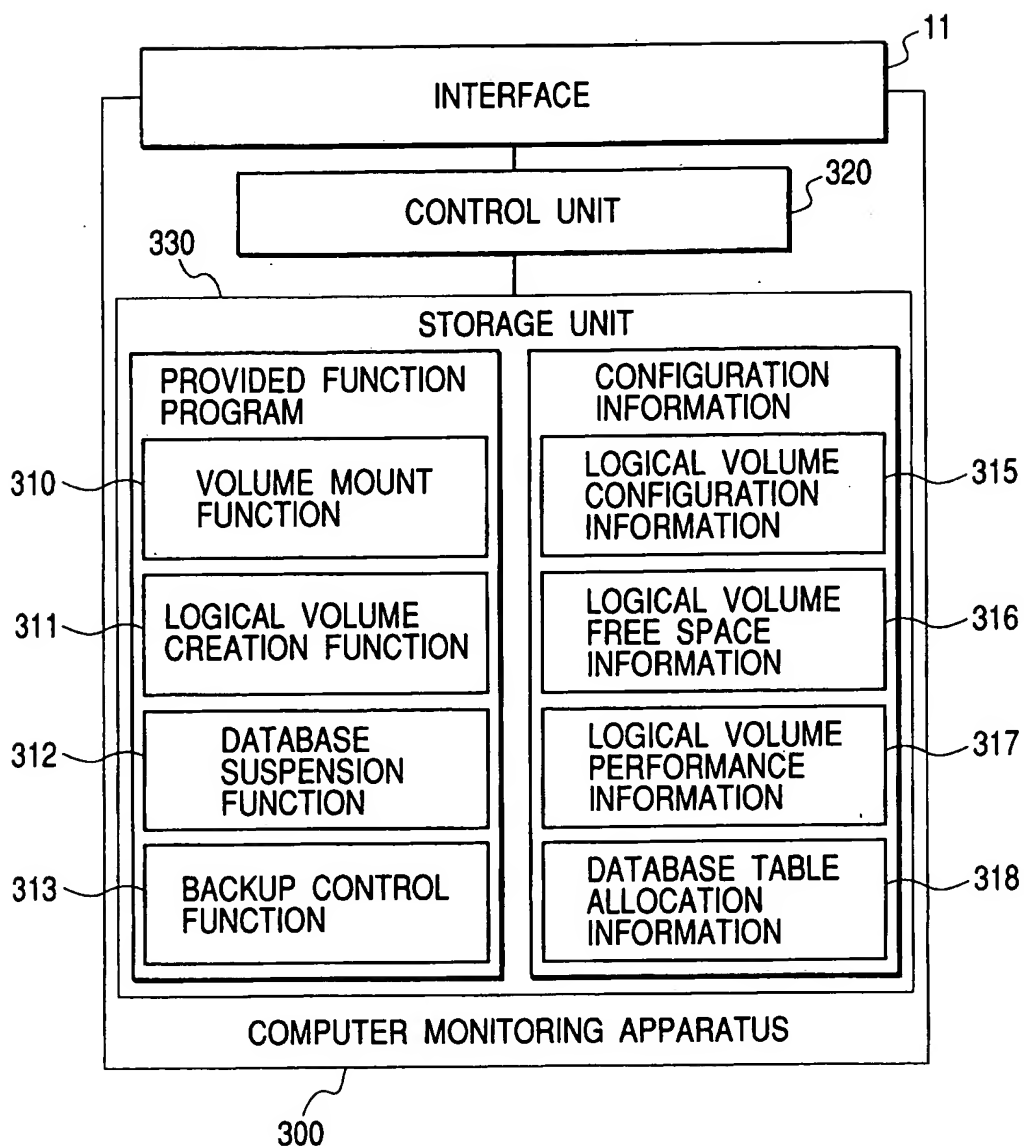


FIG. 10

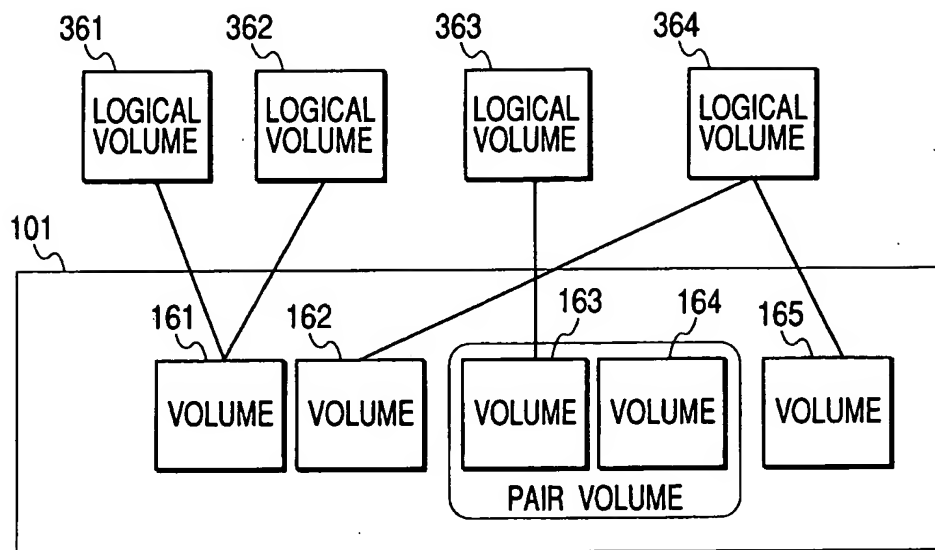


FIG. 11

315

LOGICAL VOLUME NO.	VOLUME NO.
361	161
362	
363	163, 164
364	162, 165

316

LOGICAL VOLUME NO.	FREE SPACE
361	50GB
362	100GB
363	10GB
364	200GB

317

DATABASE TABLE NAME	LOGICAL VOLUME NO.
LOG	361
ACCOUNT	363
TEMP	364

FIG. 12

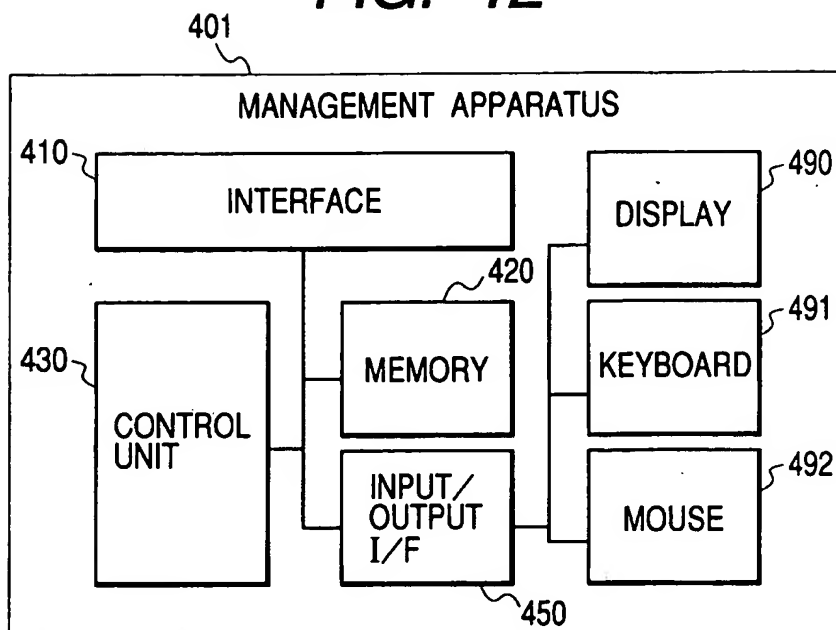


FIG. 13

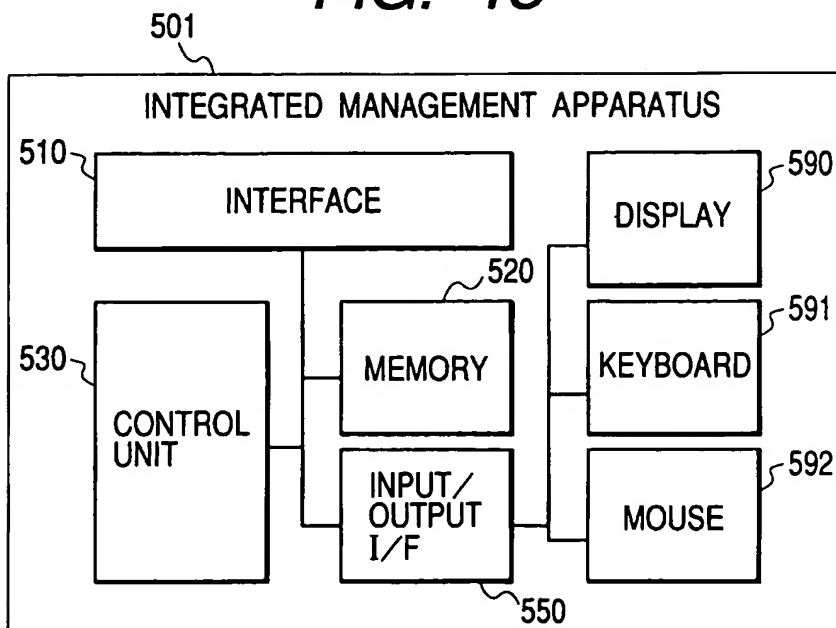


FIG. 14

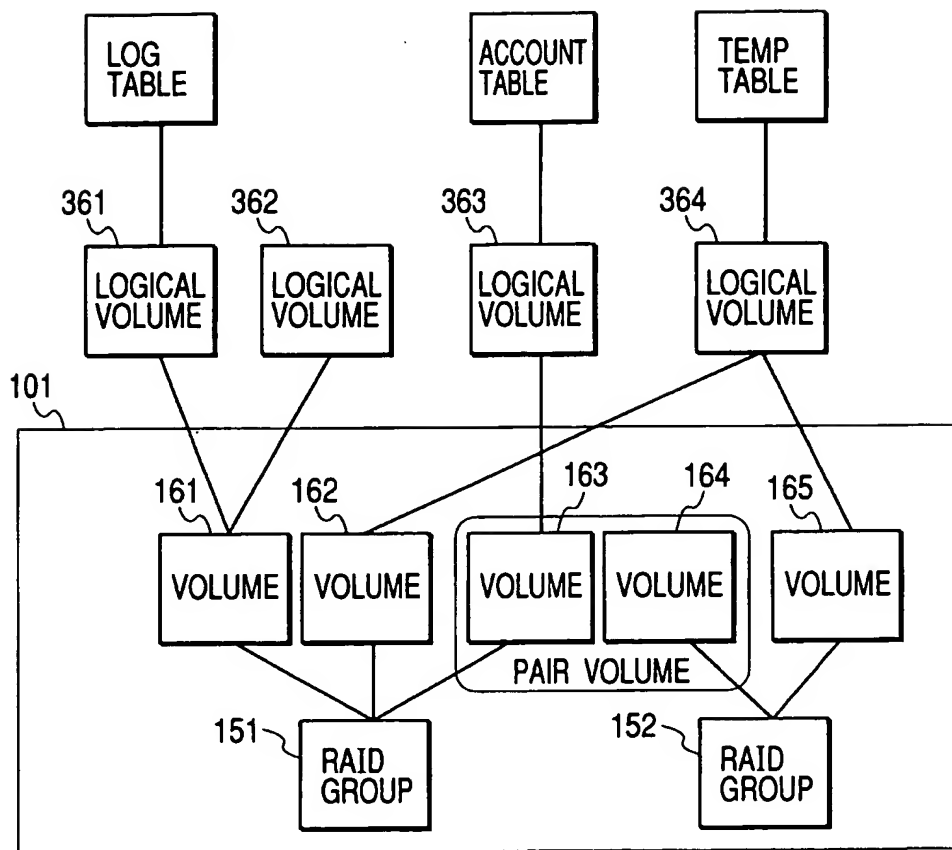


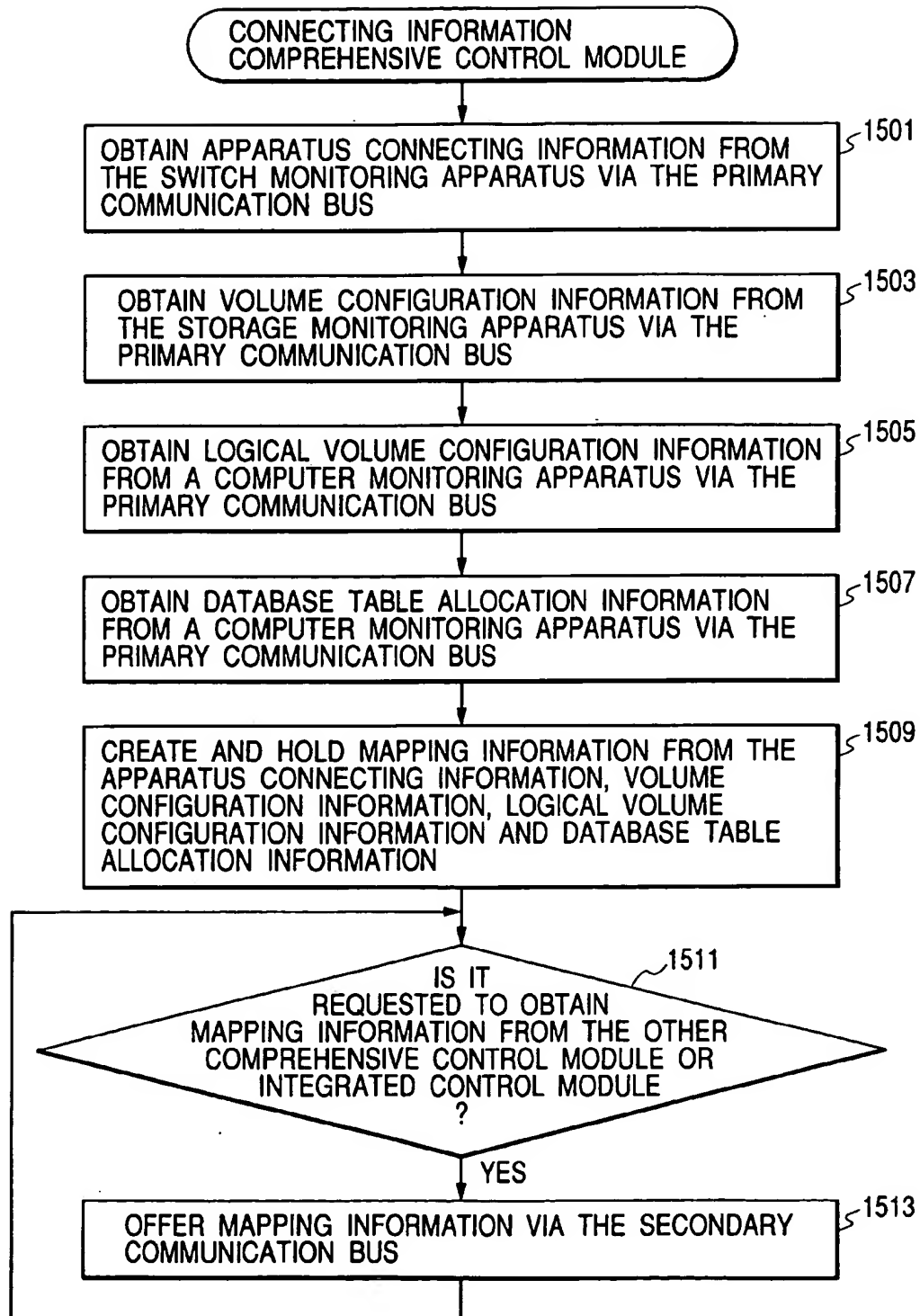
FIG. 15

FIG. 16

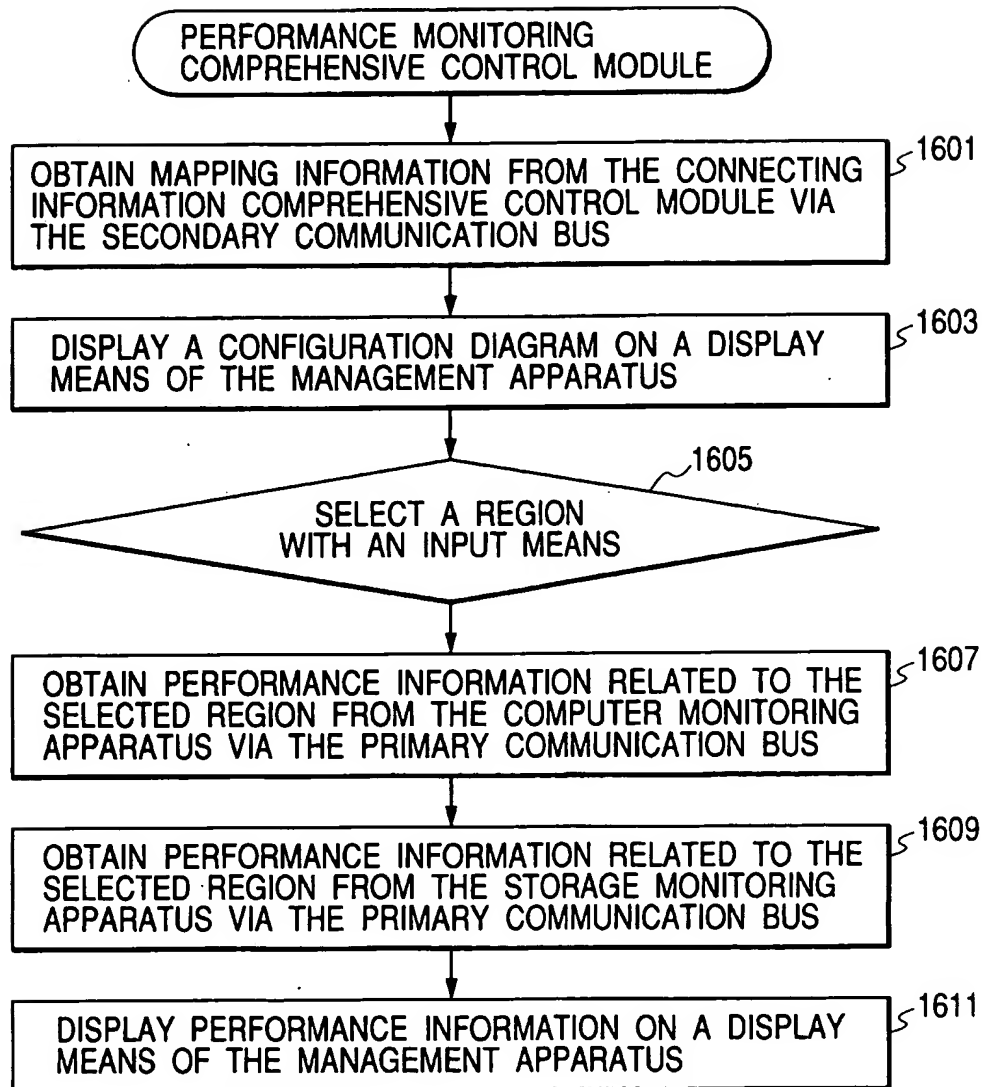


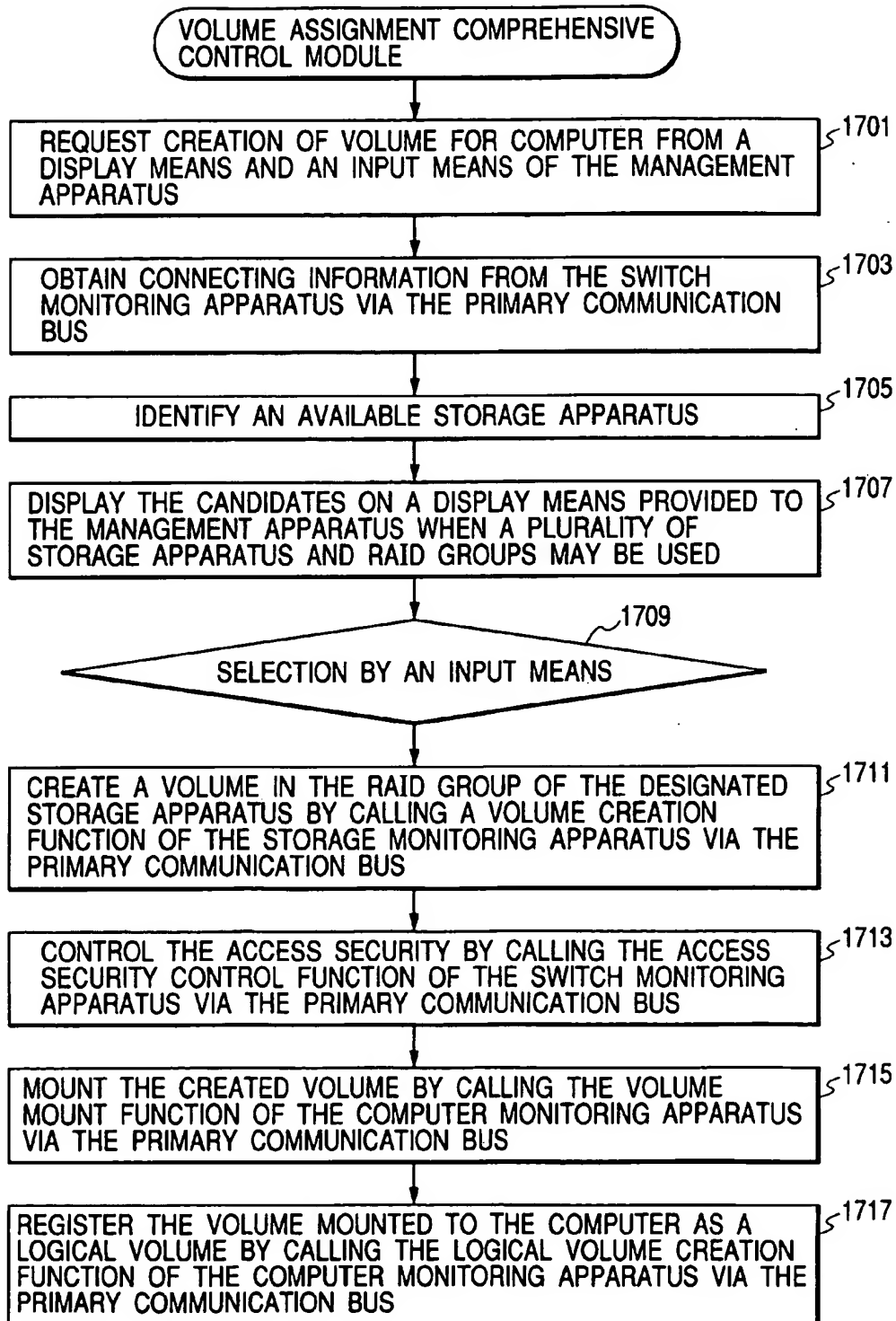
FIG. 17

FIG. 18

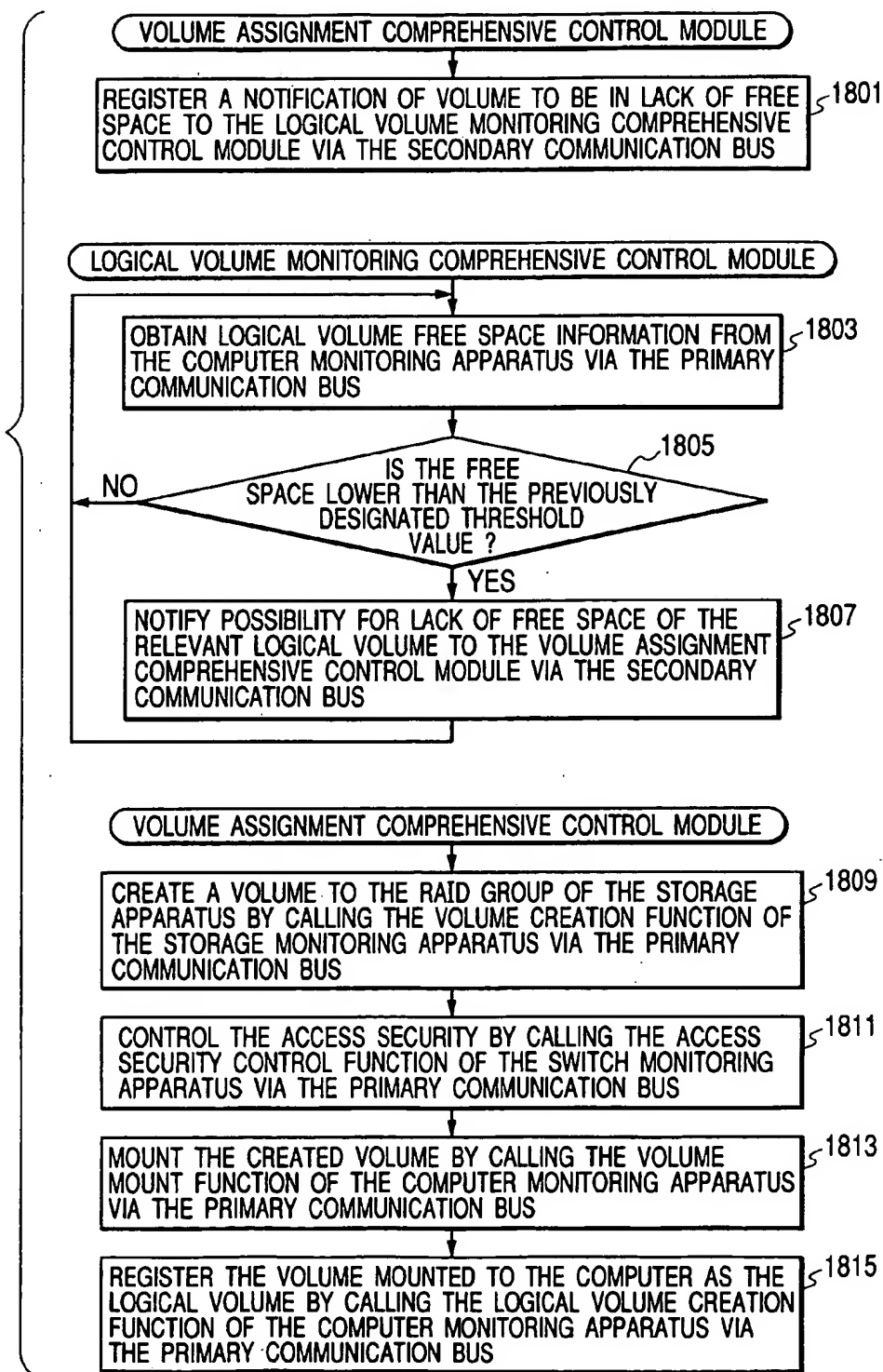


FIG. 19